

September 15, 2017

BY ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters, IB Docket No. 16-408*

Dear Ms. Dortch:

This is to inform you that, on September 15, 2017, Patricia Cooper and undersigned counsel on behalf of Space Exploration Technologies Corp. (“SpaceX”) met with Rachael Bender, Wireless and International Advisor to Chairman Pai, to discuss the certain aspects of the draft order in the above referenced proceeding on the rules and policies governing non-geostationary satellite orbit (“NGSO”), Fixed-Satellite Service (“FSS”) systems.¹ SpaceX began by expressing its appreciation of the Commission’s efforts to drive forward important updates to NGSO rules, many of which are over a decade old. Clearer rules that reflect advances in spacecraft and terminal technology and spectrum sharing capabilities will give NGSO applicants much greater certainty as they proceed with development of their systems and business plans. Other countries will certainly be watching the Commission’s implementation of NGSO rules to inform their corresponding efforts to update their national NGSO rules. Given the global nature of NGSO constellations, SpaceX encourages the Commission to support this international exchange of NGSO regulatory approaches and to engage with its regulatory counterparts through Working Party 4A and other international fora.

SpaceX noted that it supports virtually all of the updates to Parts 5 and 25 as adopted in the *Draft R&O*. Of particular note is the added flexibility gained in the new rules for emerging NGSO architectures, as seen in the decision to revise and extend deployment milestones and in the intent to eliminate international geographic coverage requirements. SpaceX believes that the new rules strike an important balance between ensuring that all NGSO applicants honor their commitments to make use of valuable spectrum and deliver much-needed connectivity and consumer services, while still allowing NGSO operators the flexibility to shape how and when they deploy their constellations. This approach enables providers to adapt to rapidly changing broadband demand

¹ See *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, FCC-CIRC1709-04, public draft Report and Order and Further Notice of Proposed Rulemaking (“*Draft R&O*”), available at <https://www.fcc.gov/document/non-geostationary-satellites-order>. Attendees at the meeting are listed in Exhibit 1 hereto.

from American consumers and the unprecedented innovation in the underlying services and applications delivered through the broadband marketplace.

SpaceX noted that the question of how NGSO systems share spectrum during in-line events is one of the most important policy areas considered in this proceeding. The Commission has correctly assumed that many NGSO systems may eventually deploy, to the benefit of American consumers, and has placed the primary onus of responsibility to determine how NGSO systems best interoperate on the NGSO operators themselves through good faith coordination with other NGSO operators.

SpaceX voiced appreciation for the Commission's efforts to develop a workable and equitable way to define in-line events to serve as default parameters where NGSO operators are unable to reach a coordination agreement among themselves. The record clearly shows that all NGSO stakeholders find splitting spectrum to be an undesirable outcome that should be avoided if possible.² Not only is such splitting an inefficient use of valuable spectrum (and for some operators, may even threaten their commercial viability³) – it also reduces available capacity and eventually services made available to the consumer. Thus, the Commission should evaluate its rules based on the extent to which they yield or mitigate the need for NGSO systems to split spectrum.

The *Draft R&O* adopts a definition of in-line events based on $\Delta T/T$ of the two NGSO systems involved.⁴ Unlike some other commenters,⁵ SpaceX opined that this approach could be workable – though it will require cooperation among NGSO operators to implement. A $\Delta T/T$ approach has particular merit as applied to space-to-Earth downlink transmissions, in part thanks to the PFD and EPFD rules that generally limit all NGSO operators. However, when applied to Earth-to-space transmissions, the specific 6% $\Delta T/T$ used to define in-line events in the *Draft R&O* could have unintended but detrimental consequences. This is because of the many and diverse types of NGSO systems architectures (LEO-MEO-HEO) that yield widely varying operational requirements for uplink performance. One cannot assume that the same in-line event parameters should apply across diverse systems with widely varying uplink characteristics in the same way they do with the fairly homogeneous downlink transmissions. A one-size-fits-all set of in-line

² See, e.g., Comments of The Boeing Company at 14 (Feb. 27, 2017); Comments of Leosat MA, Inc. at 11 (Feb. 27, 2017) (“LeoSat Comments”); Comments of SES S.A. and O3b Limited at 23-24 (Feb. 27, 2017) (“SES/O3b Comments”); Comments of Telesat Canada at 9 (Feb. 27, 2017). Unless otherwise noted, all documents cited herein were filed in IB Docket No. 16-408.

³ See, e.g., *WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System*, IBFS File No. SAT-LOI-20160428-00041 (filed April 28, 2016) (“[W]ere such a segmentation requirement to be imposed on OneWeb, it is likely that the constellation might not get completed at all.”)

⁴ *Draft R&O* ¶ 48.

⁵ See, e.g., Letter from Henry Goldberg to Jose P. Albuquerque (Sep. 13, 2017) (discussing logistical challenges of sharing information).

event rules will yield a higher frequency of cases in which the default remedy of band splitting will apply on the uplink.

As SpaceX has commented in this proceeding,⁶ when one NGSO systems generates significant uplink interference for another, very large separation angles are required to reduce $\Delta T/T$ below 6%. Large in-line angles not only increase the necessary instances of band-splitting by expanding the geographic area of coverage affected, but they also increase the likelihood of simultaneous in-line events involving three or more systems, further exacerbating the problem. In extreme cases, there is simply no separation angle that can achieve the proposed $\Delta T/T$ of 6% for uplink. This effectively places the entire geographic coverage area of a satellite within the in-line event and precludes the use of beam steering to avoid the issue. The consequence is precisely the undesirable scenario of maximized spectrum splitting and the resulting inefficient spectrum usage, contrary to the interest of all NGSO operators and the public.

Here, SpaceX previously proposed limitations on NGSO earth station uplink EIRP in order to address this issue and promote greater spectral efficiency.⁷ While the *Draft R&O* recognizes the potential for such a rule to facilitate spectrum sharing, it did not find sufficient discussion in the record to adopt such limits at this time.⁸ Yet the question of how to optimize spectrum use among non-homogeneous NGSO systems is an issue of such importance to NGSO operators and the public interest that it should be addressed, warranting at a minimum further comment and consideration.⁹ Accordingly, if the Commission concludes that a more developed record is necessary, SpaceX proposed that the Commission add a second topic to the further notice of proposed rulemaking, under which it would define in-line events for uplink transmissions as 25% $\Delta T/T$, which must be satisfied at an angle of no more than 10°. The 25% $\Delta T/T$ is a reasonably achievable parameter given the characteristics of the systems applied for in the ongoing NGSO processing rounds. By requiring that this parameter be met within 10°, the Commission would promote spectral efficiency in system design and minimize in-line events. Moreover, to the extent NGSO systems satisfy this parameter at less than 10°, they would satisfy the desire expressed by many commenters for a smaller trigger angle.¹⁰

The issue created by applying 6% $\Delta T/T$ parameter to uplink transmissions, as well as the ameliorating effect of using a 25% $\Delta T/T$ parameter instead, are illustrated in the attached presentation materials, which SpaceX provided during the meeting. These materials show the interaction of the uplinks of two sample LEO systems (SpaceX and Theia) with a sample MEO system (OneWeb), using parameters filed in the operators' respective applications. In both cases,

⁶ See, e.g., Letter from William M. Wiltshire to Marlene H. Dortch at 4-6 (Aug. 17, 2017).

⁷ See *id.*

⁸ See *Draft R&O* ¶¶ 54-55.

⁹ It is worth noting that the Satellite Communications Plan Working Group of the Commission's Technological Advisory Council is currently considering this issue.

¹⁰ See, e.g., LeoSat Comments at 12-13; SES/O3b Comments at 25; Comments of Kepler Communications, Inc. at 4 (Feb. 27, 2017).

there is no separation angle that would achieve 6% $\Delta T/T$, meaning that the entire service footprint of the LEO satellite would be the subject of an in-line event (and the default mechanism of band splitting) at all times. SpaceX also demonstrated that applying a 25% $\Delta T/T$ with 10° maximum separation angle, by contrast, significantly reduces the portion of the footprint that is subject to an in-line event, demonstrably reducing instances of band-splitting

SpaceX noted that adopting the 25% $\Delta T/T$ trigger at an angle of no more than 10° would allow the Commission to address the recognized uplink EIRP issue without having to dictate actual design decisions to NGSO operators. In fact, one NGSO system might achieve compliance by reducing the power of transmissions, while another might deploy antennas with increased gain or improved sidelobe performance, or seek to comply using some combination of strategies. But such a rule for uplink transmissions is essential in order to avoid band splitting and the inefficient use of spectrum that could significantly reduce the capabilities of all NGSO systems, and apparently threaten the commercial viability of some operators. If the Commission concludes that the current record is not sufficient to act on this important issue, SpaceX proposes that the Commission include the following questions in the further notice:

In order to promote spectral efficiency and facilitate spectrum sharing, we propose to adopt a 25% $\Delta T/T$ trigger at an angle of no more than 10° for uplink transmissions. Would 25% $\Delta T/T$ be an appropriate level to apply to uplinks? Would this achieve greater spectral efficiency while still providing NGSO operators sufficient flexibility in designing their systems? Would a larger or smaller value achieve a more optimal balance of these interests? How should we evaluate the trade-off between efficient spectrum sharing that benefits all NGSO operators and the individual preferences of specific operators?

These questions would allow interested parties to augment the record with respect to an issue already raised in the initial notice of proposed rulemaking that should be addressed for the benefit of all NGSO operators and the Commission's own commitment to maximizing spectrum efficiency.

Respectfully submitted,



William M. Wiltshire
Counsel to SpaceX

Attachment

cc: Rachael Bender



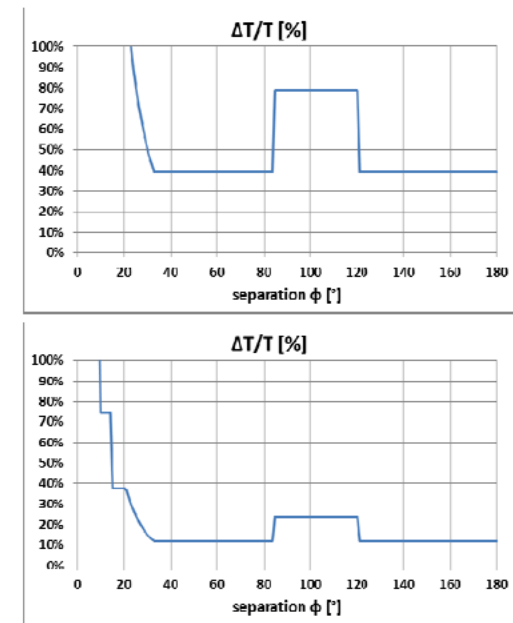
SPACEX VIEWS ON FCC NGSO NPRM

September 14, 2017



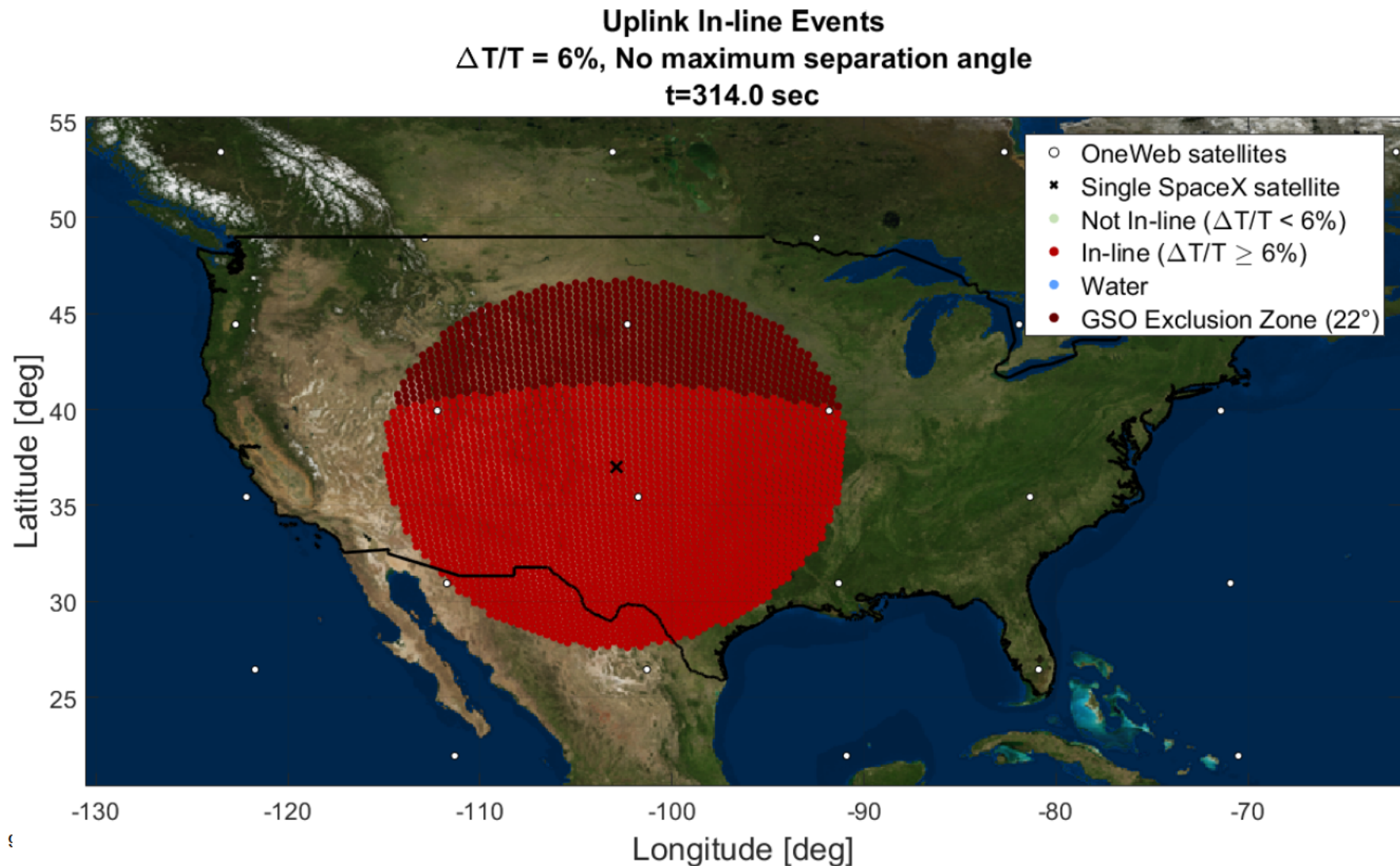
$\Delta T/T$ as Coordination Trigger

- PFD / EPFD limits ensure that satellite signals at the surface of the Earth have comparable strengths
- For downlink, $\Delta T/T \leq 6\%$ seems achievable in most cases at reasonable separation angles ($\leq 10^\circ$)
- There are no EIRP limits (on-axis and off-axis) for transmitting earth stations
- Earth stations with poor antenna rejection or transmitting large on-axis/off-axis EIRPs could require (and also force other systems to use) large separation angles or even force band segmentation
- Example: OneWeb interference on SpaceX and Theia in Ku uplink
 - All calculations based on info submitted to the FCC
- At any separation angle (up to 180°), OneWeb interference to SpaceX ($\Delta T/T$) is over 39%
 - Creates a continuous in-line event, with band splitting as default
- At any separation angle (up to 180°), OneWeb interference to Theia ($\Delta T/T$) is over 12%
 - Creates a continuous in-line event, with band splitting as default



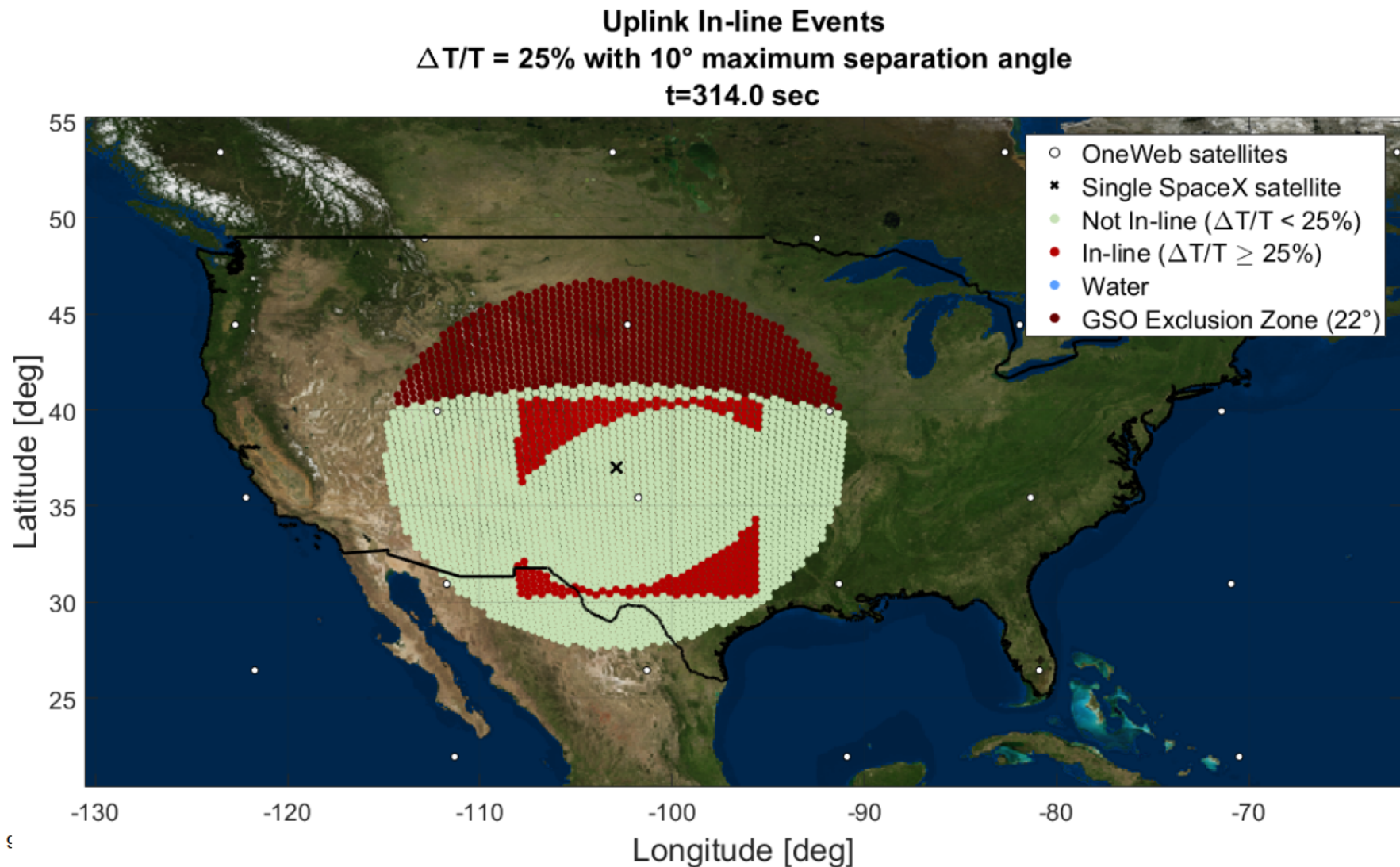
Uplink In-line Events with OneWeb from SpaceX Point of View

$\Delta T/T=6\%$, no maximum separation angle



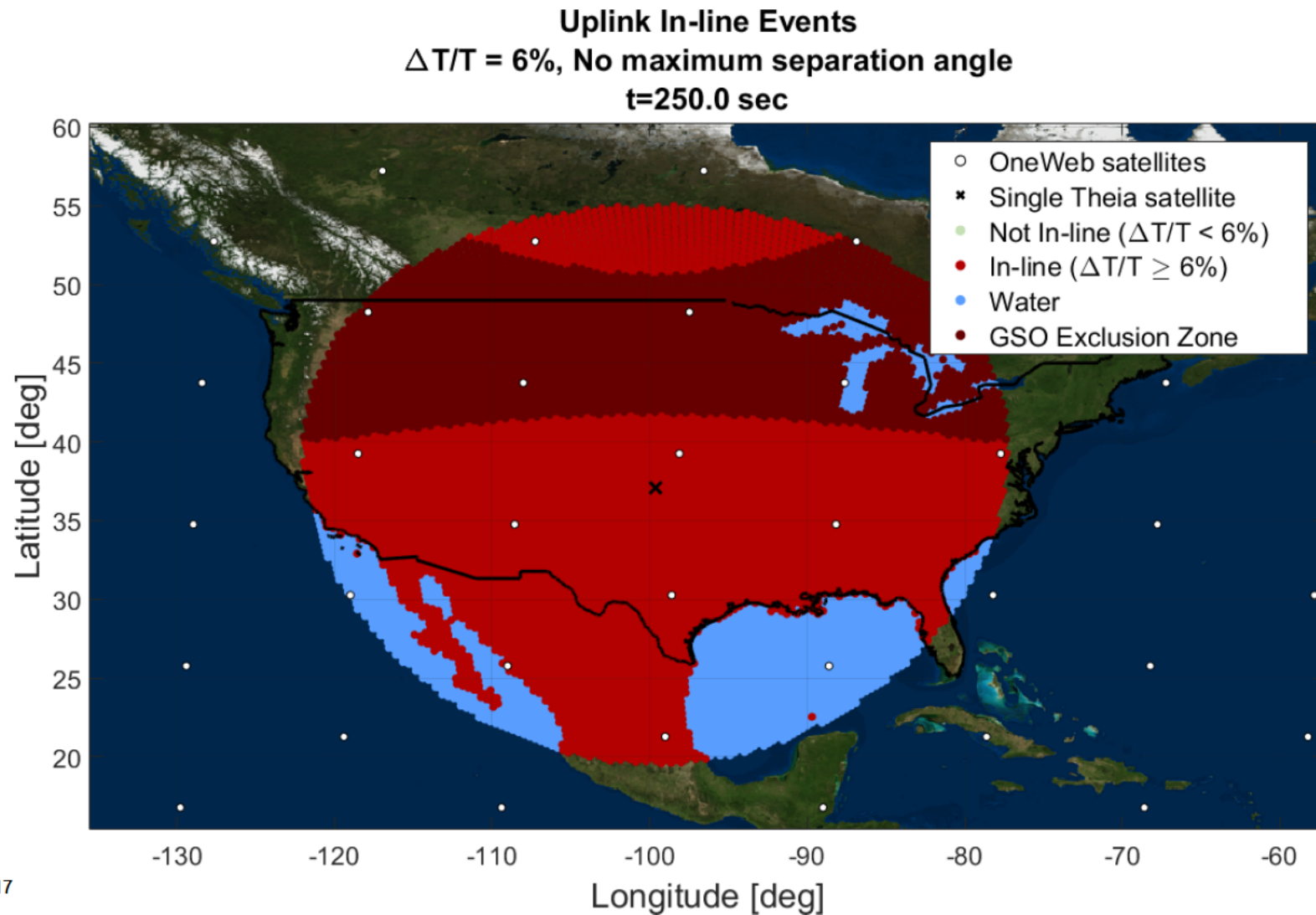
Uplink In-line Events with OneWeb from SpaceX Point of View

$\Delta T/T = 25\%$ with 10° maximum separation angle



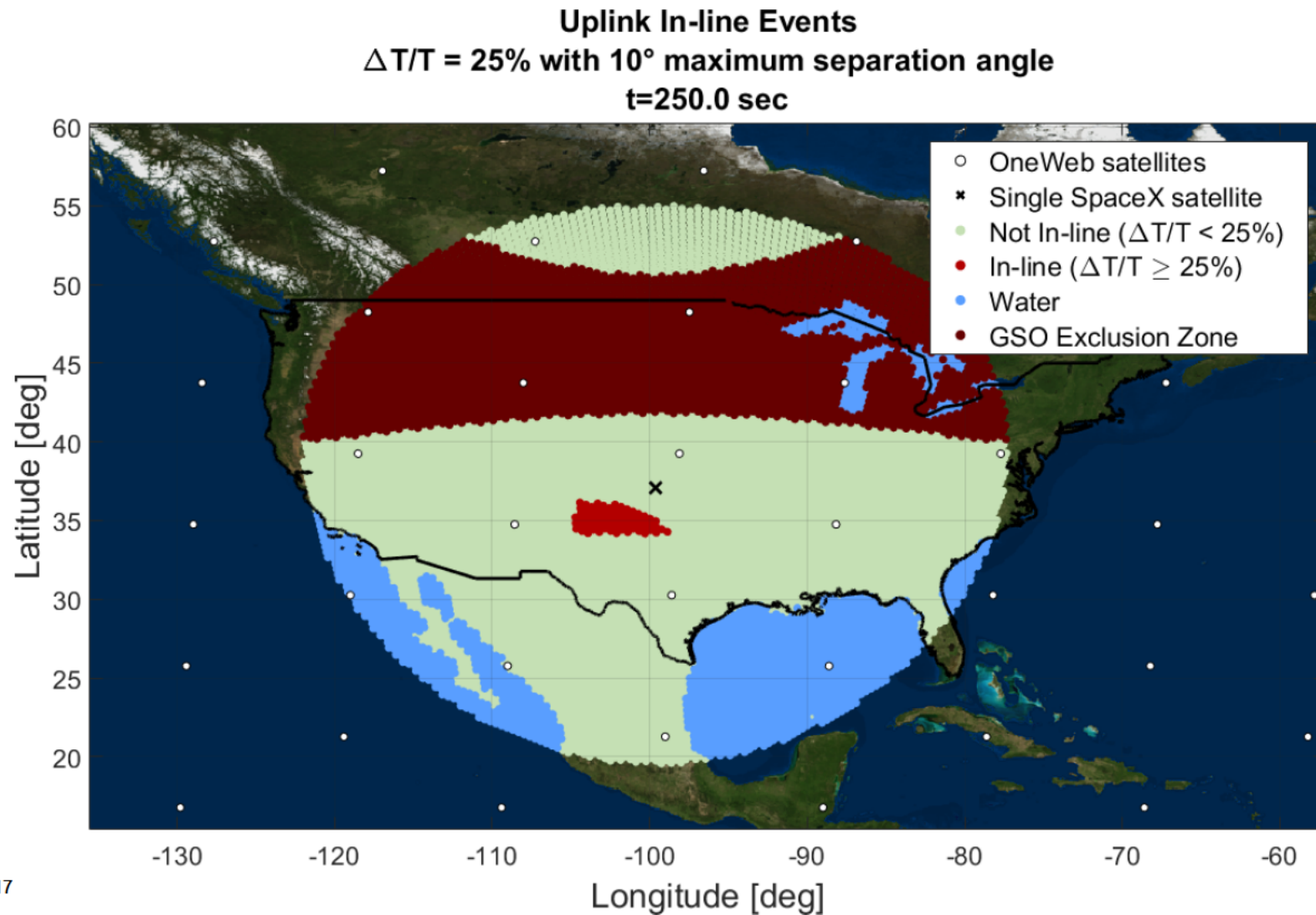
Uplink In-line Events with OneWeb from Theia Point of View

$\Delta T/T = 6\%$, no maximum separation angle



Uplink In-line Events with OneWeb from Theia Point of View

$\Delta T/T = 25\%$ with 10° maximum separation angle



$\Delta T/T$ as Coordination Trigger (MEO example)

- MEO and HEO earth stations can transmit at very high EIRP (on- and off-axis)
- Uplink interference to LEO satellites can be significant
- Example: ViaSat interference to SpaceX in Ka uplink
 - All calculations based on info submitted to the FCC for 0.6m ViaSat earth station
- At any separation angle (up to 180°), ViaSat interference to SpaceX in Ka uplink ($\Delta T/T$) is over 35%
 - Creates a continuous in-line event, with band splitting as default
- Assuming ViaSat would actually transmit at 15dB below the EIRP mask provided:
 - 25° separation is required for $\Delta T/T = 6\%$
 - 14° separation is required for $\Delta T/T = 25\%$
 - Very significant reduction in spectral efficiency at $\Delta T/T = 6\%$
 - Large angles increase the likelihood of simultaneous in-line events between 3 or more systems (thus exacerbating the problem)



SpaceX Proposal

- **Use 25% $\Delta T/T$ for the uplink, which must be satisfied at no more than 10°**
- More reasonable than 6%, given the characteristics of proposed systems
- Helps to address the disparity in uplink EIRP among non-homogeneous systems
- Not as necessary for downlinks, since PFD and EPFD limits everyone already
- 10° requirement promotes spectral efficiency in design and minimizes in-line events (though sharing beam information would help even more)
- To the extent systems can satisfy the limit at less than 10° , achieves the goal of many commenters for a smaller trigger angle
- Parties can agree in coordination to use smaller separation angles for mutual benefit



Other Issues

- Spectrum splitting during in-line events should be fair, reflecting different rules applied to different bands (BSS/FSS, GSO/NGSO bands, Radio Astronomy, etc.)
- Sharing of beam-pointing information among all NGSO system operators would significantly identify and reduce false in-line events
- SpaceX recommends creating a neutral central “clearinghouse” for in-line events to aggregate and protect confidentiality of proprietary beam-pointing data
- In certain cases, the interference during an in-line event (when spectrum is split between the two parties) is so strong that it impacts the adjacent channels.
 - Current rules do not set an interference limit for the adjacent channel
 - SpaceX proposal: $\leq 6\% \Delta T/T$





THANK YOU